M49

GEOLOGICAL SURVEY OF CANADA

A. P. LOW, DEPUTY HEAD AND DIRECTOR

REPORT

ON THE

CASCADE COAL BASIN

ALBERTA

BY

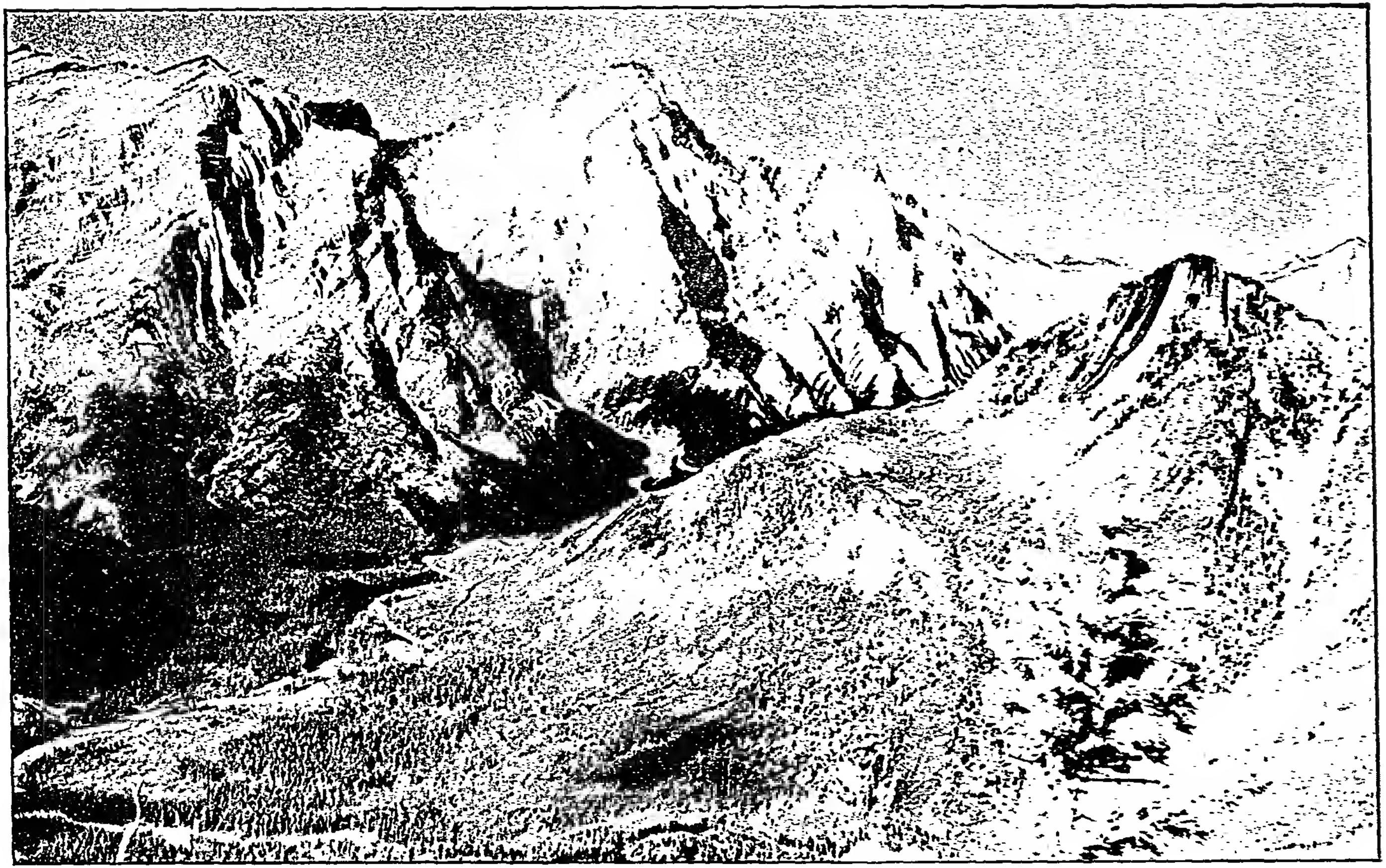
D. B. DOWLING, B.A.Sc.

OTTAWA
PRINTED BY S. E. DAWSON, PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1907

[No. 26b—1907.]

No. 94

(Frontispiece.)



26b. FOLDS IN LIMESTONE, MOUNT KIDD. KANANASKIS RIVER IN FOREGROUND.

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To A. P. Low, Esq.,

Director and Deputy Head,

Geological Survey of Canada.

Sir,—I beg to submit herewith a report on the geology of the Cascade Coal basin. An outline only of the geology and topography is given, as these are very fully illustrated in the sections and on the map sheets that accompany this report.

The body of the report deals mainly with the economic features of the area—character of the coal, thickness of seams, attitude of the beds and extent of the measures. Much time has been consumed in attending to the topographic details, and the report is, therefore, not as full as I should wish.

I have the honour to be, sir,

Your obedient servant,

D. B. DOWLING.

Geological Survey Office,

Ottawa, May 25, 1906.

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ILLUSTRATIONS

REPORT

ON THE

CASCADE COAL BASIN,

ALBERTA.

By D. B. Dowling.

INTRODUCTION.

The area illustrated on the accompanying map sheets lies within and to the east of the summit of the Rocky mountains. The sections which accompany each sheet are intended to aid the understanding of the general structure, which will be seen to consist mainly of simple types of long, narrow fracture blocks tilted up sidewise and resting against each other. There is in many cases a certain amount of overlap, and the whole series suggests that the work of mountain building progressed from the east towards the west. The structure also bears a rude resemblance to the form assumed by shore-pressed ice when fractured, and the outer cakes are pushed above those nearer the shore.

The great break in the crust of the earth which probably marked the inauguration of the mountain building forms the outer range of mountains, and those who have studied it assert that it was of great dimensions. Mr. McConnell observed at the gap of the Ghost river an overthrust of more than two miles, with an upthrust of many thousands of feet. After this great break, and the overlap of one part of the crust on another, it would seem that the lateral pressure was greatly relieved, but the west to east pressure is marked by many huge breaks and folds. The upturning of the edge along the first crack induced other fractures parallel to the first and at short distances behind. These fractures probably run along the line of sharp folds, but in each case the rocks of the western block have mounted above those to the east. If there had been no subsequent denudation each of those blocks would have been crowned on its westward sloping side by the highest beds of the original crust, but as these rocks were easily carried off there is generally but a small remnant left, and the harder beds—in this case the Carboniferous limestones—show up strongly, and form the mountain chains.

The softer sandstones of the Cretaceous, where any portion is left, are in the valleys and up against the edge of the next succeeding block. Variations in the structure occur; a fault block may have one end strongly tilted up and probably thrust higher than the other end, while the break along its front changes from a fault at the higher end to probably a sharp fold at the lower end. An instance of this can be traced in the northern continuation of Cascade mountain. The fault along the eastern face of this ridge passes into a fold before that part is reached which is shown on the northern edge of the Cascade sheet. The section at the bottom of this sheet shows a displacement near Bankhead of about 15,000 feet, vertically, between contiguous beds, but on the section at the top of the same sheet shows a fold which throws all the beds about 3,000 feet out of alignment.

In the narrow blocks, since the eastern edges of all are pushed to approximately the same level, the elevation above the sea of the western edge is higher than when the block has a more generous width. Erosion is more pronounced in the higher altitudes, and consequently there is seldom any remnant of the upper and softer rocks along the western edges of the narrow blocks.

In the wider blocks, indicated by greater distance between mountain ranges, there is a better chance of finding remnants of the softer rocks of the upper part of the section. This is very well illustrated on the map sheets and in the appended sections. The general structure is thus intimately connected with the possibilities of finding coal-bearing rocks, and then in obtaining a fair conception of the extent and position of the measures.

A short discussion of the several rock series exposed, and the general structure for each sheet, is introduced, with somewhat fuller notes relative to the coal-bearing rocks.

GENERAL GEOLOGY.

The rock formations exposed in this part of the Rocky mountains give a continuous section from the highest remaining beds of the Cretaceous down to the bottom of the Carboniferous, showing a thickness of the earth's crust for this amount of sediment—of 14,750 feet, or 2·78 miles. Below this Devonian limestones are sometimes exposed for another 1,500 feet, but still lower beds are shown in the valley of the upper part of Panther river, and these would add probably another mile to the exposed thickness. The several series briefly described in their order of occurrence in the section beginning at the highest are here given.

CRETACEOUS.

Upper Ribboned Sandstone.—In the section on the eastern face of Cascade mountain a series of thin bedded sandstone and shales appears above a strong rib of coarse sandstone which may be taken as the limiting member of the coal-bearing beds beneath. On the higher parts of the plateau south of the Bow river strong sandstone beds with occasional conglomerates may be assumed to occupy nearly the same horizon. These cap the coal-bearing series there, and are coloured on the map to correspond with the ribboned sandstone of Cascade mountain. The top of the formation is always denuded, so that the character of the series above is unknown. A thickness of 550 feet for this series has been measured to the broken beds at the fault line.

Kootanie Coal Measures.—Between two strong sandstone ribs, forming the top and bottom members, lie beds of sandstone and shale enclosing many valuable coal seams. The total thickness exposed on the Cascade river is 2,800 feet, including the heavy sandstone. In the hills south of the Bow river ten or eleven seams of coal, over four feet thick, have been found. North of Bankhead, on the slope of Cascade mountain, fourteen possibly workable seams occur.

Lower Ribboned Sandstone.—Thin bedded sandstone and shale, generally brown in colour but containing no coal, lie below the sandstone rib at the base of the coal formation. A thickness of 10,000 feet was measured on the Cascade, but this thickness may not continue to the south, although the Cretaceous as a whole does not appear to lose in thickness, and it is possible that the coal measures invade the underlying sands and shales below.

JURASSIC.

Fernie Shale.—Black shales with grey sandstones and an occasional limestone bed toward the base occupy the same position relative to the Kootanie and the older rocks beneath as similar series at Fernie, where they hold a few Jurassic fossils. Here. but few fossils were found, and they bear a similarity to some of those at Fernie. In a small exposure near the east end of Minnewanka lake a series of fossils that

26b—p. 8. MODEL OF BOW VALLEY, CANMORE TO BANFF.

appear to be Jurassic were collected some years ago by Mr. McConnell, so that the correllation does not seem to be in doubt. These shales frequently outcrop in the area now mapped, but the best section is that on Cascade river, where a measured section gave a thickness of 1,600 feet.

PERMO-TRIASSIC

Upper Banff Shale.—The Permian age of these beds is not well proven, but their position between Jurassic and Carboniferous rocks warrants the assumption until definite proof be obtained. They are capped by yellow dolomitic limestone, possibly 100 feet in thickness, but the mass of the formation is a reddish weathering, dark, sandy shale. In distant exposures, these beds have been mistaken for the Cretaceous which lie above. The thickness is very uniform at about 1,200 to 1,300 feet.

CARBONIFEROUS.

Rocky Mountain Quartzite.—This is a series of fine-grained sandstones generally of a light yellow tint, and as they are the top of the harder rocks of the section they frequently form the lower slopes of the westward side of the fault block, and can be seen on the eastern sides of the large valleys. The lower part of this formation is of a greyish-white, and very closely resembles the underlying limestones. The summit of Pigeon mountain is of this sandstone, yet at a distance it might be taken for a limestone. A thickness of 1,600 feet would be a good average for the formation.

Upper Banff Limestone.—These are light bluish and grey limestones. The top beds are thicker than those below, where grey and dark shales appear in bands towards the middle of the formation, and the limestones become thinner bedded. In the thin bedded members many corals are found, and in the more shaly beds they weather out in very perfect specimens. The change to the shales of the division beneath is not abrupt, and the dividing line, therefore, is not well marked, especially as north and south from the typical locality near Banff, limestone bands appear in the lower shale members. The thickness may be said to vary from 2,500 to 3,000 feet.

Lower Banff Shale.—As remarked above, the division between this and the upper limestone is not well marked. The series is generally a dark grey shale, but is often brownish weathering from the presence of a small percentage of iron. This formation varies in thickness from 1,000 to 1,500 feet.

Lower Banff Limestone.—This consists of a heavy bedded series of limestones without shaly partings. The formation is readily discerned on the broken face of a mountain range, as it is not weathered to regular slopes, but forms bold escarpments generally tinged with yellow and brown on weathered surfaces. Conspicuous cliffs of this limestone face the valley of the Bow from the Rundle range. It forms the lower and middle peaks of the Three Sisters, and is also seen in the steep wall that towers above the mining town of Bankhead. The average thickness of the formation is about 2,000 feet.

DEVONIAN.

Intermediate Series.—A few exposures of the yellow and brownish coloured dolomitic limestones are to be seen low down along the face of the Rundle range. They appear in greatest thickness in the Vermilion range at the gap of the Panther river. There they are noticeable for the ribboned appearance from alternate bands or beds of light and dark yellow. The lower portion forms the eastern edge of the range, and is faulted so as to rest upon the red beds of the Upper Banff Shale.

The maps that show the distribution of the various formations enumerated above need no very extended explanation, and the general geology of the section across the basin is so well discussed by Mr. McConnell in Part D., Annual Report, Vol. II. (N.S.), that the present report will deal more specifically with the coal-bearing areas and the coal mines in operation.

GENERAL NOTES ON THE PHYSICAL STRUCTURE.

WIND MOUNTAIN SHEET.

Three parallel mountain ranges are shown on this sheet. In the northeastern corner the valley of the Bow river cuts through the eastern one, while at the south another in which the Kananaskis flows crosses two of them. The general structure shown by the geological colouring and the sections at the top and bottom of the map is the result of two parallel faults with downthrow on the eastern side, thus forming three great blocks all tilted to the west. The fault which runs through the middle of the sheet shows a displacement at the south of 10,000 feet and in the vicinity of the Three Sisters about 12,500 feet. The one to the west passing near the Spray lakes shows less displacement (about 6,000 feet), so that the Cretaceous rocks were left originally at a great elevation and have since been denuded. The eastern block is wider than the others, and has not suffered so much tilting, although its eastern edge has been raised very high by a sharp upturn. The beds forming the softer portions covering the harder limestones are not all eroded away, and a large area of the coal-bearing beds consequently remains.

On the high land just to the east of Wind mountain, in the centre of the sheet, these coal measures occupy a synclinal trough, but there is evidence that the western margin of this upturned series of rocks, in the under beds at least, suffers another flecture that bends them down again, and is thus in part overridden by the limestone of the mountain mass to the west. On the Kananaskis river, where the valley is cut down through nearly the whole of the Cretaceous series, the lower beds dip toward the fault and, continuing south a short distance, are cut off as they reach the fault line. Two synclinal folds are developed in the measures in front of the fault: these split the formation into two narrow much compressed troughs which rise to the south and disappear in the mountains. The effect of the great pressure from the west is shown not only in the pushing up of these blocks against each other but also in the crumpling of the measures against which they rest. The Cretaceous beds being generally soft sandstones and shales naturally give way by bending and crumpling, but in the limestone ranges other folds appear. A series of waves, small near the contact line, traverse the range from behind Mount Kidd through and beneath Wind mountain, and reach the face of the range near the Three Sisters. The lowest peak of this group is merely a block of the same hard limestone which forms the middle one, and a reference to the section at the top of the Wind Mountain sheet will illustrate this. These small folds increase in size, and the illustration showing the folds in the south face of Mount Kidd will serve to show the remarkable amount of bending that is possible in the limestone without fracture. South from this point the increase in lateral and vertical movement leads to a final break, and the continuation of the Kananaskis valley for a short distance is eroded along this fracture. The illustration which is used as a frontispiece is the one referred to, and shows the point to which the erosion of the valley along this steep fold was carried. Northward these folds reach the line of the fault beneath Wind mountain.

CANMORE SHEET.

Along the eastern portion of this sheet a line of fault is developed, but where it should cross the Bow river there is only a sharp fold. The effect of this additional break is to allow the central block to tip more steeply to the west, and the coal measures are at a greater slope than the same beds in the sheet to the south. On the slopes of Pigeon mountain the general dip is seen to be quite uniform, but on the north side of the Bow river there is, on the slopes of Grotto mountain, a more abrupt change. In the main mass of the mountain the beds dip very gently to the west, but along the western margin there is quite an abrupt downturn which in some places looks like a break. An attempt to illustrate this is given in the subjoined sketch.

BEND IN STRATA, GROTTO MOUNTAIN.

Owing to the tilting of the beds at a high angle to the west the coal rocks come lower down in the valley and dip toward the fault line. As the sliding of the limestone in the Rundle Mountain ridge was upward over part of these beds, a series of waves might be expected in them parallel to the fault line. Those that are found have, however, a pitch downward to the south, which seems to denote a pressure and movement not at right angles to the fault line but from a more westward direction. A possible explanation may lie in the fact that the fault line north of Bankhead or Anthracite is deflected to the north and dies out, or changes, to a fold of lessening dimensions. This gives then a pivotal point on which a large block can be assumed to have turned, which would allow of a sliding of the limestone upward from a direction at a slight angle with the fault line. The part of the field thus affected extends from near Anthracite to the foot of the hill below the Three Sisters, but the beds to the east of a line running north and south through Canmore are not so much disturbed, although west of this line they dip downward through a series of curves, as already noted. At Anthracite the seams do not appear affected by this series of small waves, but there is instead a much larger fold pitching downward in nearly the same manner as to the south. The cause of this fold is possibly traceable to the change in the direction of the further continuation of these beds up the valley to the north, and also to the fact that here the maximum displacement along this fault line is found. As mentioned in the discussion of the Wind Mountain sheet, the throw of the fault at the south edge of the sheet was 12,500 feet; it has reached at least 15,000 feet at the northern edge of the Canmore sheet, or rather in the vicinity of Anthracite. The fault which starts north of the Bow river and runs east of the Fairholme range has a throw of 6,500 feet as it crosses Minnewanka lake.

The face of Rundle mountain, as seen from Bow valley, shows a typical section of the rocks of the lower part of the Carboniferous. The heavy bedded Lower Banff limestone stands out in almost vertical cliffs, above which the thinner bedded and more easily eroded shales and limestones form gentler slopes.

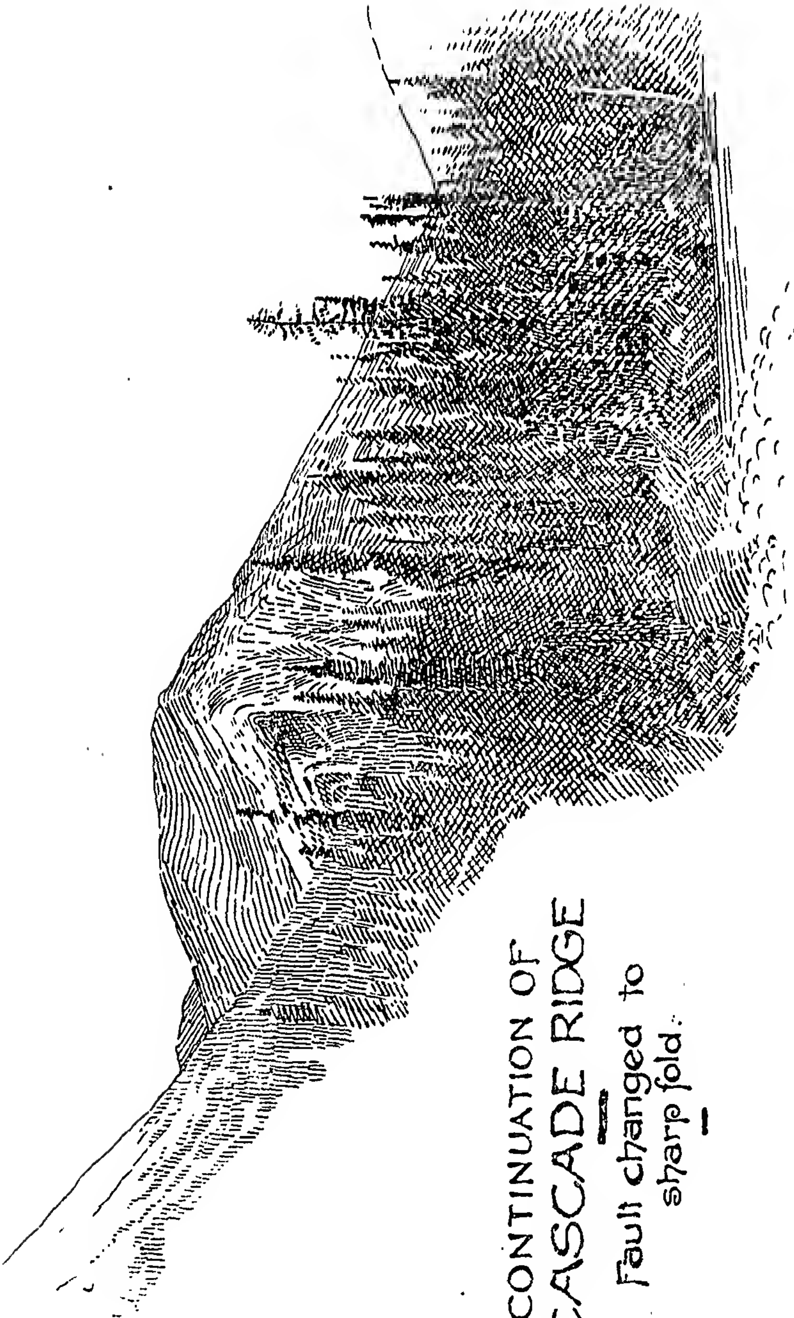
The same beds are repeated in the Sulphur range to the west by a similar fault line to that in front of Rundle mountain. The throw of this fault behind the Three Sisters is about 6,000 feet. Northward the throw does not seem to be so great, but the difference is made up by the beds of the Rundle block dipping down very steeply and making a synclinal fold in front of the fault line. This deep fold penetrates so far beneath the surface that many of the springs that find their way up along the beds and the fault are of a high temperature. They are situated approximately along the line of fault, and must come from a great depth, as the temperature in some of them is above 100 degrees.

The break in the range by which the Bow passes between Rundle and Cascade mountains is no doubt due to several cross faults. These might be expected in this place, as this is the point at which there is a change in the direction of the mountain ridges, and one of the main breaks of this series is prolonged eastward through the Fairholme range, along which line the valley occupied by the waters of Minnewanka lake has been eroded. Stony Squaw and Tunnel mountains are but remnants from the great rock mass that formerly joined the two ranges to the north and south. Other cross faults are indicated in the gaps on both sides of the Bow valley near Canmore.

CASCADE MOUNTAIN SHEET.

The line of fault which starts east of Grotto mountain in the Canmore sheet is continued northward through the next cutting across Minnewanka lake, and has a displacement of about 6,000 feet throughout this sheet. The geology of the block that is let down on its eastern side is mapped northward to the vicinity of Mount Aylmer, but from that point for a few miles northward the colours are merely projected to meet the outlines as they were seen from the east branch of the Cascade river, north of the centre of the sheet, and changes may have to be made in the details.

A second and smaller fault, confined to the area represented on this sheet, cuts along the face of Palliser range and crosses the outlet of Minnewanka lake. It appears to die out in both directions, changing to folds with lessening displacement.



CONTINUATION OF CASCADE RIDGE

Fault changed to sharp fold.

The great fault which forms the western boundary of the Cretaceous coal-bearing rocks through the area shown on both the sheets to the south is here deflected to the north by about twelve degrees, and, at the north end of Cascade Mountain ridge, is continued as a reversed fold with its axis dipping slightly to the north. This fold is broken across in several places by small cross faults—now weathered out to form diminutive valleys which divide the ridge into a series of small hills that maintain a general alignment. The first break at the end of Cascade mountain is illustrated in the sketch on page 13, and shows the remarkably sharp fold assumed by the quartzites and limestones.

In the block which fronts this range the coal-bearing beds are present, and are found along the east flank of Cascade mountain. They are rather high up the mountain side at the north end of the ridge. Beyond this the stream swings more to the west and the coal rocks disappear. The lower beds—the Fernie shales—continue, and come round the end of the ridge into the next depression to the west.

The next fault line west of Cascade mountain is a continuation of that which runs up the spray at Banff. It also makes a bend to the north similar to the change in direction of the fault in front of Cascade mountain. The change in direction also suggests a cross break, where the Bow valley cuts through this range. The Vermilion range seen from the east shows along its summit rocks of the Lower Banff limestone. with the yellowish beds of the Intermediate series forming the lower slopes. In discussing the faults through the country to the south this fault was given a throw of only about 6,000 feet. In the section of the Panther river the displacement is double this amount, and the lateral movement has been over 14,000 feet.

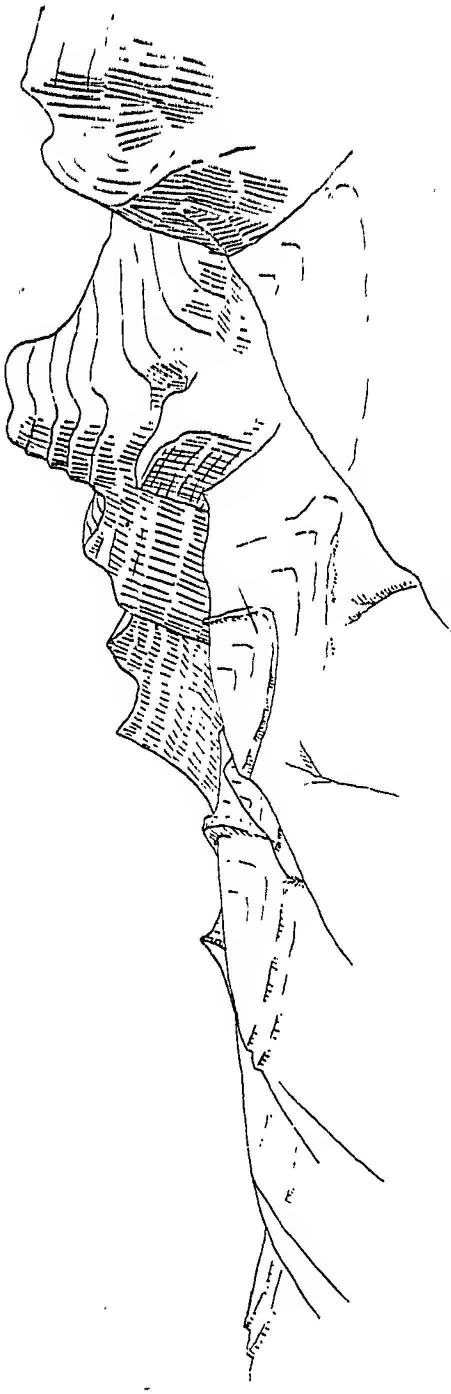
PANTHER RIVER SHEET.

The eastern part of this sheet shows part of a block of westward dipping beds cut off by the fault that runs along the eastern edge of the Palliser range. The amount of displacement now shown by the present position of the beds is about 6,000 feet at the south edge of the sheet, but this increases to the north, and at the Panther river is about 8,000 feet. In this part, which is where the eastern block has sunk lower than at any other part, a basin of coal-bearing beds is found dipping toward the west. Eastward these measures rise in heavy folds, but have suffered great erosion. Remnants of the lower parts of some of these folds still remain, crowning the summits of the lesser hills that lie between the mountain ranges. The wider valley to the west between the Palliser and Vermilion ranges is floored with the Cretaceous and Jurassic rocks, which may be said to form a trough overlapped at the north by the thrust up rocks of the Vermilion range. In the centre of the valley the trough is shallow, so that the coal rocks are limited to the higher points, and these again are found to be badly folded, so that it would seem that but little of the area should be classed as economically valuable. In the northern part, where there appears to be an overlap, there seems to be some chance that the beds dipping to the fault line may continue for a sufficient distance to make them valuable.

On the section which is made to cross the centre of the sheet it will be noticed that at either edge of this basin the underlying rocks come up in trough form, but are bent down again to the west. In nearly every exposure along the lines of fault the heavy blocks seem to have been pushed up over the down turned edges of the rocks to the east of the line of break, with the exception perhaps of rocks west of Stony Squaw mountain, where there seems to have been an upturn toward the fault line.

THE WIND MOUNTAIN COAL-BEARING AREA.

The structure of the block illustrated on the Wind Mountain sheet is already briefly described. The coal-bearing rocks occupy a partly dissected plateau rising from the eastern face of this high mountain ridge. It is cut very deeply by the valley of the Kananaskis and a small branch from between Mount Kidd and Wind moun-



WIND MOUNTAIN AND CRETACEOUS BEDS OF PLATEAU IN FRONT OF IT.

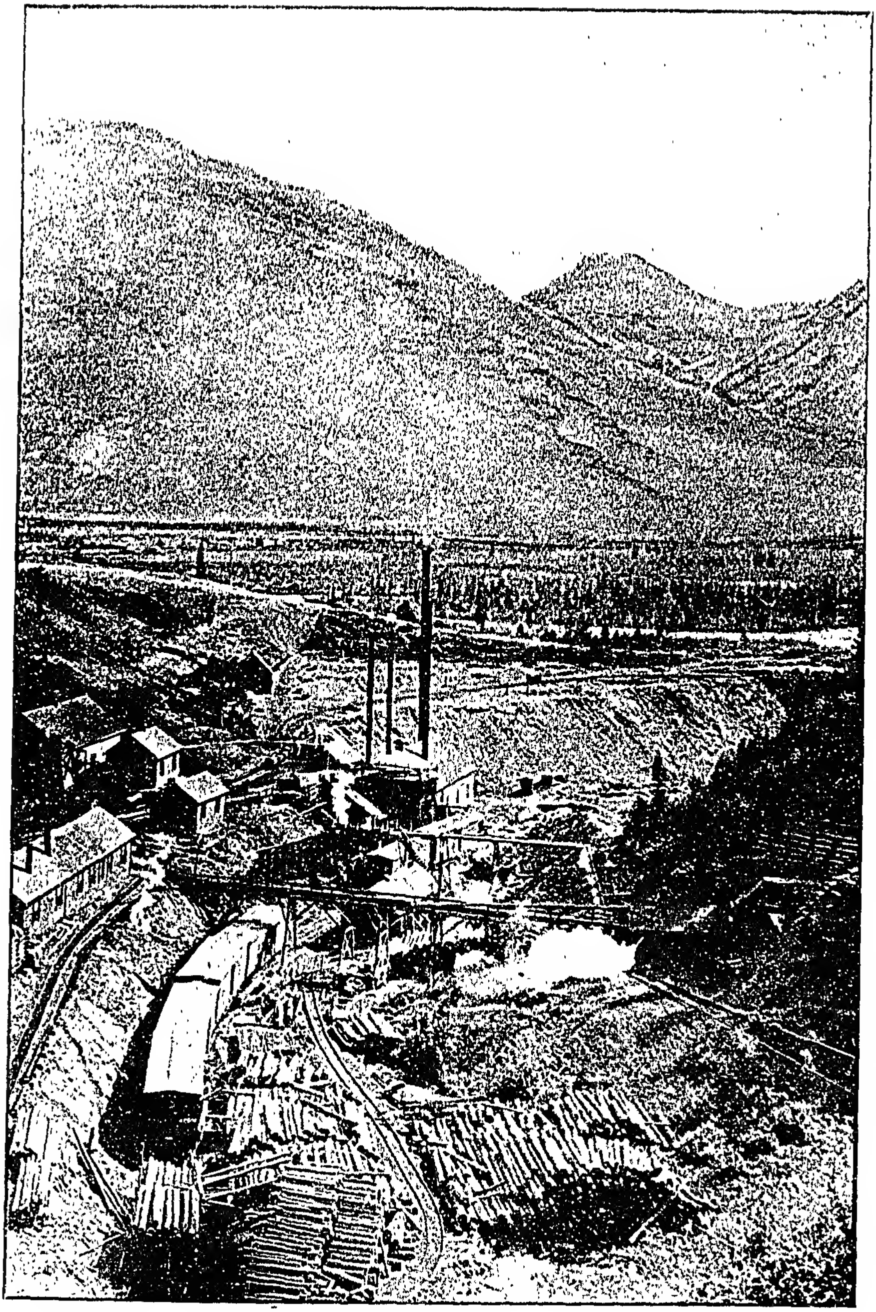
tain. The lower part of the coal measures, as seen in the Kananaskis valley, although they are cut by the fault—the dip of this fault plane being about 60° S.W.—is partly overridden by the thrust up limestone of the western side of the fault line. In the higher part of the coal measures, where these have not been removed, they are seen to have been bent back by the upward movement of the rock mass of the Wind Mountain ridge, and have thus formed a shallow trough. This structure, in the highest part of the plateau, can be seen from the Bow valley and even better from the top of nearer hills. The sketch submitted is from a hill just south of the Bow river and east of Three Sisters mountain. The trough form seems to be carried through all the high parts of the plateau, but in the valleys cutting west to the mountains the lower beds are carried quite near the fault line before being pushed up. To the north and south of this central area there is more of a tendency in the lower beds to dip downward as the fault line is approached, and it seems that there would be no good reason to compare the structure of the whole of this area to that of a trough. As many of the very promising coal seams are in the lower parts of the measures, these might reasonably be predicted to continue under these hills, dipping easily at the eastern edge to the west, but soon assuming a nearly horizontal position, which would be maintained to well in toward the fault line before being bent up. These seams could not, however, be expected to reach the surface again, as from the centre of the trough to the fault line there is not room for a return of all the beds beneath, and most of the pushed parts of the beds stop at the fault line.

South of the Kananaskis river the measures bear against limestone that has been very much crushed back and folded and faulted, so that they have been greatly denuded.

South of the hill called 'The Wedge' a gap is cut through and brings a stream from the south along the Cretaceous beds to join the Kananaskis, which occupies a parallel valley to the west. The southern extension of the Cretaceous, which lies south of the map sheet, is, therefore, greatly denuded, and is also divided by two synclinal folds with two narrow troughs that rise higher in the hills to the south, disappearing in very narrow strips in the mass of mountains behind those bordering the east side of the upper waters of the Kananaskis.

The northern part of the sheet drains to the Bow river from this plateau, and as access to it is not difficult the hills north from Wind mountain will probably be mined.

An old opening was made years ago on a seam which was uncovered in one of the gullies east of the Three Sisters, and which was found to be very good steam coal. The subsequent opening of mines nearer to the railroad discouraged this enterprise until greater demand arose. The gully in which this old mine is situated is very steep, and a section was measured in the next gully to the east as it was more accessible. The measurements are supplied by Mr. D. D. Cairnes, who made a careful examination of this section.



26b.—p. 16. Canmore Coal Mine.

Number.	Section.	Ft.	In.	Character of Coal. Moisture. p.c.	Volatile. p.c.	Fixed carbon. p.c.	Ash. p.c.
1	Coal	2	6				
	Sandstone and shale	21	0				
2	Coal	3	0				
	Sandstone and shale	76	0				
3	Coal	3	6				
	Sandstone and shale	94	0				
4	Coal	15	6	3·5	13·1	77·9	5·5
	Sandstone	10	0				
6	Dirty seam coal	10	0	2·6	12·4	81·2	3·8
	Sandstone	35	0				
7	Coal	4	0				
	Sandstone	70	0				
8	Coal	1	6				
	Sandstone	12	0				
9	Coal	4	6	1·0	12·5	78·0	8·5
	Sandstone	7	0				
10	Coal	1	6				
	Sandstone and shale	8	0				
11	Coal, mixed with shale	6	0				
	Sandstone	3	0				
12	Coal	1	0				
	Sandstone and shale	16	0				
13	Coal, dirty	3	0				
	Sandstone	53	6				
14	Coal	3	6				
	Sandstone and shale	20	0				
15	Coal, dirty	2	6				
	Sandstone	27	0				
16	Coal	1	0				
	Sandstone and shale	6	0				
17	Coal	0	6				
	Sandstone	15	6				
18	Coal	4	0	2·5	11·5	78·5	7·5
	Sandstone, streaks of coal	76	0				
25	Coal, probably upper Marsh seam	8	0				
	Sandstone and shale	66	0				
26	Coal	2	0				
	Sandstone	16	0				
27	Coal	1	6				
	Sandstone	29	0				
28	Coal	6	0				
	Sandstone	10	0				
29	Coal	7	0				
	Sandstone	53	0				
	Sandstone, streaks of coal	67	0				
32	Coal	2	0				
	Sandstone and shale	10	0				
33	Coal	4	6	2·5	9·5	83·5	4·
	Sandstone	12	0				
34	Coal	2	0				
	Sandstone and shale	9	0				
35	Coal	1	0				
	Shale	20	0				
	Sandstones and shales	100	0				
39	Coal	5	0				
		1048	6				
	Coal seams four feet and over	10					

CANMORE COAL-BEARING AREA.

Reference to the Canmore sheet shows the coal-bearing rocks to form a narrow band stretching the length of the sheet and occupying about the middle. This represents beds nearly all dipping to the west and probably cut off at the fault line, the plane of which dips to the west about 60 degrees.

A line south through Anthracite will about follow the trough of a large fold which lessens to the north but broadens out and descends toward the south. The beds come up nearly vertical before turning down again, and at the point indicated by the northern edge of the sheet they are all dipping to the west again. Southward from this fold there is probably a distance in which these westward dipping beds are not otherwise disturbed, but as Canmore is approached a series of minor folds are encountered that have been discussed in the chapter on the physical structure of the region. The southeastern limit of this series appears to be at the base of the small plateau north of Three Sisters mountain, and the limiting line can roughly be given as running north and south just to the east of Canmore. The beds east of this line are lying in a rather flat trough, the western edge, in the higher parts at least, turning upward toward the fault line as though pushed up by the over-ridden beds to the west of the fault line.

Openings have been made on the coal seams of this area in several places and extensive mines have been in operation, though, at the present time, mining is confined to the vicinity of Canmore. The mine at Anthracite from which a considerable amount of hard coal has been taken is at present closed. The old Cochrane mine at Canmore is closed, though the measures will probably be tapped by the workings at the Canmore mine a short distance to the south. The Canmore mine is situated at a gully west of the town, and another auxiliary opening has lately been made a mile to the south in order to add to the output. Our knowledge of the measures has been gleaned mainly from the workings of the mines, and notes relating to them are here introduced.

CANMORE MINE.

The main openings are in a small gully on the west side of the Bow river near the town of Canmore. The first mine in this neighbourhood—the Cochrane mine—was opened on the same side about a mile farther up the river, and a spur to it was made from the railway. When it was closed down and the openings for the present mine were made the spur was continued down the west side of the river. Another opening is now being put in a mile southeast of the Canmore mine on an outcrop called the Sedlock seam, and the railway spur is being continued to it. This will considerably increase the output of the mine without taxing the plant in operation at the main slope. The workings are generally towards the south from the main slope, but some mining has been done toward the northwest. The abandoned workings of the Cochrane mine, records of which do not appear to be available, are a great menace if they happen to be on the same seams, as they are full of water.

The coal measures outcrop along a small stream that comes from the gap leading to the White Man pass. Several seams outcrop, and on No. 2 a slope has been put down. A section along this part of the creek would give the impression that the measures occur in a series of waves sharpening to the west, and that probably the same bed was repeated. The section given in the mine shows that the beds are crumpled in a series of waves, but that the general dip of the seams is about 50 degrees toward the Rundle range. The waves along the beds seem to be the result of the pressure and partial over-riding of the mountain mass from the west. That this pressure was not at right angles to the line of faulting is shown by the fact that the waves do not run with the line of strike but pitch downward toward the south. This feature is discussed in the chapter on the general structure of the region.

The workings are on six seams, with a slope on No. 2 seam which reaches a depth of over 600 feet. The general section, with the several coal seams, is given in the following summary, commencing at the highest seam:—

Seam No. 6.—Coal, 4′ 6″, with a small shale parting in the middle.
Rock, 245′.
Seam No. 5.—Coal, 5′ 3″, soft and broken.
Rock, 30′ to 100′.
Seam No. 4.—Coal, 3′ 1″, generally bright and clean.
Rock, 25′.
Seam No. 1.—Coal, 5′ 8″, with 8″ slate.
Rock, 40′.
Seam No. 3.—Coal, 5′.
Rock, 15′.
Seam No. 2.—Coal, 4′.

Detailed sections of each seam, and analyses of the coal from various points in the mine, as far as could be obtained, are here given:—

Seam No. 6.—This is reached by a tunnel from No. 5, is the highest of the series mined and was the last to be prospected. The horizontal distance from No. 5 is reported as 350 feet. The seam has 4′ 6″ bright coal, with a small parting in the centre, and from a sample obtained twenty feet from the surface appears to be very clean. An analysis of a small sample supplied by Mr. A. Stewart was made in the laboratory of the survey by Mr. F. G. Wait, and gave the following results:—

Moisture	0·49
Volatile combustible matter	16·04
Fixed carbon	81·14
Ash	2·33
	100·00

Seam No. 5.—This is a crushed seam in many parts, and suffers pinching out where the curves or waves in the plane become sharpened up. The coal thus crowded out helps to swell the thickness in the other parts, so that in following the workings an increase in thickness is generally succeeded by a sudden decrease. On one of the gangways along this seam to the north of the hoist a thickness of twelve feet was attained, but in a short distance this diminished to a few inches, and often the seam is lost altogether for a short distance. The following analysis, which is supplied by the mine operators, will give a general index of the character of this coal:—

Moisture	1·10
Volatile matter	14·66
Fixed carbon	78·38
Ash	5·20
Sulphur	0·66
	100·00

Another sample submitted to the Trail smelting works and analyzed by R. T. Wales is much harder and has less ash:—

Moisture	2·00
Volatile combustible matter	12·90
Fixed carbon	82·40
Ash	2·70
	100·00

This last sample is no doubt taken from the unbroken and more compact parts of the seam. Experiments in washing this coal showed that most of the ash was in the finer particles or in the softer portion of the seam, and therefore harder to get rid of. In some of the other seams there is a large amount of slate, but this is easily picked out. As No. 5 is an easily worked seam the tendency is to put as much of this soft coal as possible in the output, but the amount of ash in the fine coal was against it. A washing plant has been installed, and it is possible that the general high grade of the coal will be maintained.

Seam No. 4.—The section where this seam outcrops in the creek at the mines shows a dip of about 65 degrees. Small bands of slate are in the seam, but there is 3′ 1″ of clean coal. The analysis of the weathered coal is:—

Moisture	1·25
Volatile matter	13·52
Fixed carbon	81·30
Ash	3·47
Sulphur	0·46
	100·00

In the mine the coal appears to be of the same character. From north of the hoist the analysis gives, for dried coal:—

Volatile matter	13·00
Fixed carbon	84·50
Ash	2·50

South of the hoist another sample gives:—

Volatile matter	13·8
Fixed carbon	82·2
Ash	4·0

Seam No. 1.—The coal in this seam is pretty well split up by shale partings, but they are readily separated out, and the coal is of fair quality. The section here given is in descending order at a point 100 feet southeast of the main slope:—

Roof, sandstone.	
Slate	0′ 3″
Coal	0′ 6″
Mining	0′ 6″
Coal	1′ 6″
Mining	0′ 1″
Coal	0′ 9″
Mining	0′ 2″
Coal	2′ 3″
Mining	0′ 1″
	5′ 8″

Analysis by R. T. Wales:—

Volatile matter	12·6
Fixed carbon	83·4
Ash	4·0

The seam is pinched out to a few inches in the tunnel at the foot of the main slope, and to determine whether this extra crushing had hardened the coal a sample was analyzed by Dr. Hoffmann, but the results are negative:—

Moisture	0·43
Volatile matter	15·10
Fixed carbon	81·74
Ash	2·73

Seam No. 3.—Section in gangway north of main hoist:—

Roof, sandstone.

Coal	2′ 3″
Slate	0′ 3″
Coal	2′ 10″
Mining	0′ 2″

Floor, sandstone.

Analysis by R. T. Wales:—

Volatile matter	11·8
Fixed carbon	84·4
Ash	3·8

Seam No. 2.—This is the lowest seam worked. Others below this have been prospected but are not clean enough. Several sections at different points in the mine are furnished by the manager, Mr. O. E. Whiteside:—

Section No. 1, 100 feet northwest of tunnel, upper lift—

Good coal	0′ 6″
Slate	0′ 2″
Fair coal	2′ 8″
Shale	0′ 8″
Coal	0′ 1″
Slate	0′ 2″
Coal	0′ 5″
Slate	0′ 2″
Coal	1′ 0″
	5′ 10″

Section No. 2, 50 feet southeast of tunnel, upper lift—

Coal	0′ 6″
Slate	0′ 2″
Sandy coal	2′ 6″
Slate	0′ 9″
Coal	1′ 2″
Slate	0′ 0½″
Coal	1′ 7″
	6′ 8½″

Section No. 3, 60 feet northwest of rock tunnel from No. 1 to No. 3, lower lift—

Roof, slate.

Fair coal	0′ 10″
Sandy coal	2′ 4″
Slate	1′ 2″
Extra coal	1′ 6″
	5′ 10″

Section No. 4, northwest of second tunnel, lower lift—

Mining	0′ 11″
Coal	1′ 7″
Mining	0′ 7″
Slate	1′ 2″
Coal	0′ 8″
Slate	0′ 1″
Coal	0′ 6″
Slate	0′ 2″
Coal	0′ 6″
Slate	0′ 0½″
Coal	0′ 3″
	6′ 5″

Section No. 5, southeast of second tunnel, lower lift—

Bony coal	0′ 6″
Mining	0′ 3″
Slate	0′ 0½″
Coal	1′ 5″
Slate	0′ 0½″
Mining	0′ 7″
Slate	1′ 6″
Coal	0′ 6″
Slate	0′ 3″
Coal	0′ 6″
Slate	0′ 0½″
Coal	0′ 11″
	6′ 6½″

One analysis by R. T. Wales, of the Canadian Smelting Works, Trail, B.C., is given for coal from this seam, but the locality is not recorded:—

Volatile matter	14·7
Fixed carbon	79·0
Ash	6·3

Sedlock Seam.—One other seam is being opened along the bank of the Bow river a mile southeast of the mine. This is to the east of the outcrop of the seams in the mine, and appears to be on the eastern edge of the crumpled area. The main part is in a broad, shallow trough, with the eastern edge upturned to nearly vertical, and outcroping along a nearly straight line running southward. The trough broadens to the south and for the most part it is supposed that the coal will be about horizontal. If the outcrop of the western upturn be followed southward into higher ground there is reason to suppose that it will be found to curve back and join some of the seams of the mine. If a connexion can thus be made with the mine a saving in undergound haulage will be made.

The character of the coal in this seam is very like that of No. 4, but it is somewhat thicker in section.

Coal	0′ 5″
Slate	0′ 2″
Coal	0′ 3″
Slate	0′ 1″
Coal	4′ 6″
Mining	0′ 1″
	5′ 6″

Analysis by St. Louis Sampling Works:—

Moisture	0·93
Volatile matter	12·78
Fixed carbon	82·99
Sulphur	0·75
Ash	2·55
	100·00

Analysis by M. O. Hersey:—

Moisture	0·04
Volatile matter	14·03
Fixed carbon	82·11
Sulphur	1·07
Ash	2·82
	100·00

The general section of the seams in the mine as given above is a rough approximation only. The general dip of the seams is about 50 degrees toward the mountain range to the west of the valley. A series of folds runs along the plane of the seam, and have a pitch of about 20 degrees toward the south. Where these folds cross the main gangways the plan of these latter show curves, and in the case of the larger folds the curves are reversed like S. On the sharper parts of the curves the coal is often pinched out.

There are scarcely any faults in the measures. Nearly all the trouble in following the seams arises from the presence of these crushed folds.

The coal is raised from the first two levels on a double track slope on No. 2 seam. The first level is 130 feet below the mouth of the slope, and the opening to it from the slope is by a short tunnel to No. 4 with a sort of drawbridge that is let down on to the tracks of the slope when cars from this level are to be raised.

At the second level, which is the one from which most of the coal comes, 340 feet below the mouth of the slope, the tracks cross each other through a narrow opening, so that in the event of an accident to the cable or coupling the runaway car leaves the track at the curve and strikes the bulkhead. This simple device seems to be very effective, as no serious accident has occurred since its installation.

The first fold that is encountered crosses near the foot of this slope, and the seam is pinched out to a few inches. Another fold follows at about 500 feet along the gangway to the southeast, causing a deflection in the plan of the roadway. At this turn the cars of coal from the lower or third level are hauled up a slope that runs along the bottom of this trough. A compressed-air engine with winding machinery is installed on the second level at the head of this second slope. The vertical lift from the third level to the second is 216 feet.

Southeastward from the main hoist, for nearly a mile, the measures are quite regular, but at this distance a fold is again encountered, and the gangways all curve more or less sharply round the saddle and trough through all the beds. As might be expected, the lower beds under the trough and the upper ones over the saddle have easier curves, and there is less pinching out of the coal. The sharpness of the curves also decreases as the trough is followed downward.

GAS IN THE MINE.

Although the coal is a semi-anthracite, and not inclined to be gassy, there still seems to be pockets or small reservoirs of gas that, when tapped, are dangerous. These blow-holes do not last very long, but practically close up portions of the mine for a time. They are encountered in the rock tunnels as well as in the coal seams, and may be on the lines of crushed out coal seams. Safety lamps are used with every caution,

and accidents are not frequent. The ventilation is by means of several fans driven by steam.

Extracts from 'Reports on the efficiency of various coals used by the United States ships, 1893-95,' Bureau of Equipment, Washington, 1895, pp. 26-27:—

'Thirty tons of Canmore steam coal were received for test at Vancouver, British Columbia. About one half of it was fine coal, the rest consisting of small lumps with the admixture of a small percentage of bigger lumps of the size of 4 to 6 inch cube. It resembles in appearance English Cardiff coal; also its chemical composition, according to H. W. McNeill's table, is similar to that of the mentioned coal, having a little less percentage of fixed carbon and a little more of volatile matter than Cardiff coal. Its calorific quality is superior to that of the Cardiff, and it burns out quicker. Like the Cardiff, it burns with no smoke, and is a semi-bituminous coal. It makes a small hard clinker which does not adhere to the grate bars, and it does not coke in the furnace. The percentage of ashes is small, and less actually than given in the table, as some of the fine coal fell through the interstices of the grate bars, thus being unable to give out any heat, but increased the ratio of the refuse. The tubes were not in need of sweeping during the three tests. The ashes appear of a light greyish colour, with yellow streaks......'

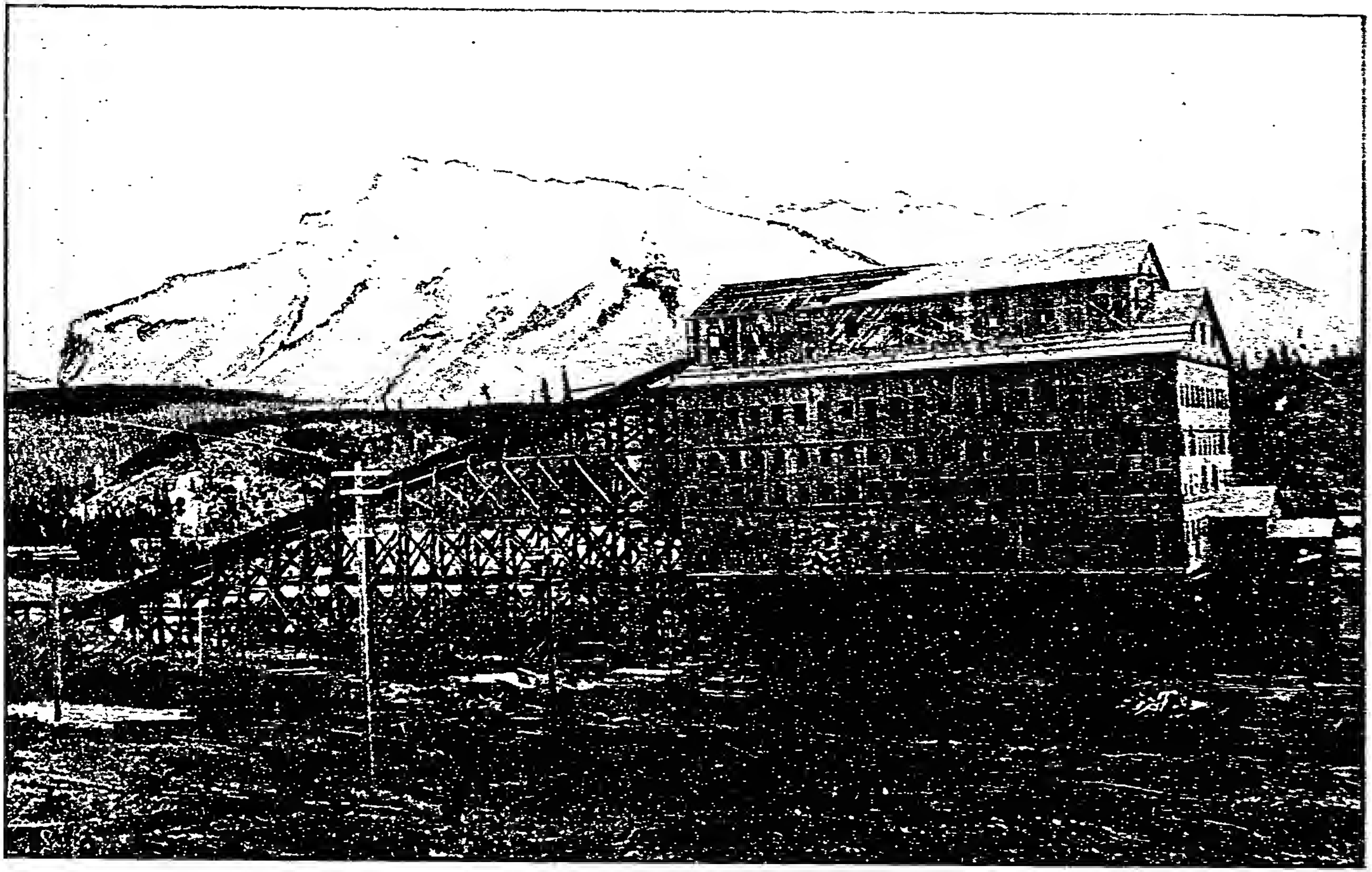
Analysis at Navy Yard, Washington, D.C.:—

Moisture	0·730
Non-combustible volatile matter	0·370
Combustible volatile matter	9·716
Fixed carbon	86·367
Sulphur	0·141
Ash	2·676
Phosphorous	0·007

Extracts from table of results from boiler tests on United States steamship *Mohigan*:—

TABLE OF DEDUCTIONS.

Name of Coal.	Reported. Horse power.	Coal burned per hour.	Coal burned per H. P. per hour.	Calculated Knots per ton of Coal.
Speed 50 revolutions approximately.		Lbs.	Lbs.	
Canmore	644	2,133	3·31	10·0
Blue Canyon Washington	649	2,237	3·44	9·6
Navy Washington	739	3,056	4·133	8·0
New Vancouver Nanaimo	702	3,021	4·302	7·7
Speed 40 revolutions approximately.				
Blue Canyon	391	1,219	3·11	15·1
Canmore	396	1,234	3·12	15·1
New Vancouver	362	1,137	3 137	15·0
Navy Washington	357	1,442	3·98	12·0
Speed 30 revolutions approximately.				
Navy Washington	195	782	4·00	18·9
Canmore	180	763	4·23	17·9
New Vancouver	181	803	4·425	17·1
Blue Canyon	178	830	4·66	16·0



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Breaker and Screening House, Bankhead.

Anthracite Coal Mine.

The first coal seam located in this district was on the Cascade river nearly opposite the present mine at Bankhead. When the measures were found in a gully near the railway mining operations were commenced at what is called Anthracite. A slope was put down on the first seam, and several other seams were discovered above and below. The coal was very free from ash and had a high percentage of fixed carbon, so that it was classed commercially as anthracite.

The output was never very large owing to the restricted demand during most of the time that this mine was in operation. That the coal is so hard may probably be caused by the great pressure to which it was subjected—partly on account of the great throw of the fault and a possible overriding of the measures by the rocks of the mountains to the west, but also to the presence here of a great fold similar in structure to those at Canmore but of greater dimensions. This fold occurs just in the deflection angle made by the change in strike of the measures—that is, between the direction of the strike along the Bow valley and the production south of the strike of the northern portion up the Cascade valley, making an angle of 12 degrees.

An opening was made in a small gully to the east of the Cascade river, and mining operations were commenced on beds dipping down into this fold. On account of the great denudation of the valley of the Cascade river, filled in again by gravel deposit, the beds could not be safely followed down through the trough and over the saddle to the far side without running into the water-laden gravel of the river. In the northern part of the mine where the trough was shallower the western upturn showed a slight bending to the west, and this, if it could have been followed far enough, would have led down into the seams that are on the northern part of the property.

The sandstones below the coal can be traced northward to cross the Cascade river, and it seemed rational to suppose that the coal seams should follow the same direction.

The mining operations were continued only long enough to extract the coal from the seams within the fold, and little prospecting was done on the northern and larger part of the property. The mine was robbed of its pillars in 1904, and all the plant was removed. The particulars of the thickness of the seams and their relation to each other should be preserved, and a condensed statement is here added.

The workings were carried out on two levels, with a counter above the upper one. The depths below the mouth of the slope are: Counter, 120 feet; 1st level, 270 feet; second level, 435 feet. The slope is on seam No. 1.

Five seams were worked, having the following relation to each other, beginning at the highest:—

Seam B—Coal, about	4′ 4″
Rock	85′ 0″
Seam A—Three small seams	7′ 0″
Rock	75′ 0″
Seam No. 1—Two small seams	4′ 0″
Rock, about	75′ 0″
Seam No. 2—	2′ 2″
Rock	30′ 0″
Seam No. 3—	3′ 4″

Sections of the Seams.

Seam B, 100 feet south of tunnel—

Mining	1′ 0″
Slate	0′ 7″
Coal	4′ 4″
Mining	0′ 6″

Seam A, at top of new slope—

Mining	0′ 3″
Coal	1′ 0″
Slate	0′ 1½″
Coal	4′ 9½″
Mining	0′ 2″
Rock	1′ 6″
Coal	2′ 10″
Mining	0′ 4″
Total coal	8′ 7½″

Analysis of coal from seam A:—

Volatile matter	7·65
Fixed carbon	88·72
Ash	3·63
	100·00

Seam No. 1, section in tunnel—

Roof, shale.

Bone	1′ 3″
Coal	2′ 0″
Bone	0′ 2″
Coal	0′ 5″
Slate	0′ 2″
Mining	1′ 2″
Slate	0′ 1″
Coal	0′ 5″
Slate	0′ 4″
Coal	1′ 2″
Mining	0′ 2″

Floor, slate.

Seam No. 2, in tunnel—

Roof, hard shale.

Coal	2′ 2″
Shale	0′ 4″
Mining	0′ 6″

Seam No. 3, in tunnel—

Roof, slate.

Mining	0′ 10″
Coal	1′ 2″
Slate	1′ 0″
Coal	2′ 2″

Bed, sandstone.

Northwest of the mine near the railway bridge, three seams were opened in the hillside. These are probably some of the upper beds that are to the west of the fold. They are the only ones prospected west of the mine, and had they been of better character there is no doubt that extensive mining would have followed, but as they were dirty work on them was soon stopped.

Drifts were run in on the upper and lower seams. The upper one is the heavier, but is cut up by many slate partings, as will be seen in the two sections below:—

Upper seam section at outcrop—

Mining and slate	0′ 9″
Coal	1′ 5″
Slate	0′ 2″
Coal	2′ 2″
Slate	0′ 2″
Coal	2′ 3″
Slate	0′ 0½″
Coal	0′ 11″
Slate	0′ 1″
Coal	0′ 4″
Slate	0′ 5″
Coal	0′ 5″
Total coal	7′ 6″

Section in drift, 62 feet—

Mining and slate	0′ 7″
Coal (good)	1′ 0″
Slate	0′ 3″
Coal (partly sandy)	4′ 9″
Mining (some streaks of coal)	1′ 9″
Total good coal	5′ 9″

Lower seam, section at outcrop—

Mining	1′ 6″
Coal	3′ 10″
Slate	0′ 2″
Coal	0′ 10″

CASCADE MOUNTAIN COAL AREA.

Along the face of the Cascade mountain a heavy block of Cretaceous rocks dips to the west toward, and apparently under, the limestones. In several of the small gullies running down from the face of the mountain coal seams were found and prospected for the Pacific Coal Company. They are now being mined from the south end of the ridge, where it is cut by the Cascade river nearly opposite the point where the first discovery of coal was made. The numerous seams prospected on the face of the slope have not all been traced as far as the crossing of the Cascade, but two strong ones near the bottom of the measures were traced from Creek No. 4 south, and, as before mentioned, temporary entries were made on them. A permanent entry by a long tunnel through the gravel of the lower part of the valley is now in operation, starting from near the level of the Cascade river. This point is 186 feet below the temporary entry, or 234 feet if measured along the pitch of the seam. This lower level for the entry adds considerably to the amount of coal above the haulage way. Another advantage is the easier access for a railway spur from the main line. A suitable location for shops is found here, and an extensive plant, consisting of breaker, boiler-house and machine shops, has been put in operation. The haulage in the mine will be by compressed-air motors.

References to the progress of the work and notes on the measures will be found in the Summary Report for the following years: 1903, p. 90; 1904. p. 113, and the Summary for 1905.

The southern end of this field consists of a monoclinal block of Cretaceous rocks dipping to the west, partly over-ridden by the limestone of Cascade mountain. This overthrust has made some impression on the rocks composing the block. The two

lower seams on which work is progressing are well protected by heavy beds of sandstone and the shearing and pressure of the overthrust have caused little damage to the coal. The one above has suffered much more owing no doubt to weaker covering beds, and there is evidence that there has been sliding and bending of the overlying rocks. The sliding plane seems to have been mostly along the plane of this coal, which is seam No. 2½. In the beds immediately under the mass of the mountain little crumpling could take place, and they must have slidden bodily or in sections at different planes. In the beds at a distance from the overlying mass less sliding took place, and the consequence is that there has to be a crumpling of the upper measures, a sort of gathering or pleating (to use a homely phrase) of the beds in front of the load. The rolls thus made would at the sliding plane be filled with broken material, and there would be a local thickening of the series along the face of the overthrust mass. The folds at Canmore are formed in somewhat the same way.

The bulging in this seam was noted at several places. In the prospect work at the top of the hill, half a mile north of the mine, No. 2 seam showed 100 feet of crumpled coal. This was found to occupy a triangular section—the foot wall being at about the normal slope, but the roof nearly vertical. A short distance below the seam had about five feet of coal. In a cross-cut to this same seam at the temporary entry on No. 2 seam the rocks were apparently undisturbed to near No. 2½, when the dip increased and the seam was found standing about vertical. Farther on the dip reversed, and, where work stopped, the rocks were nearly horizontal. This points to a possibility that this tunnel passes beneath another of these rolls or pockets of broken coal. The foot wall of the seam was smoothed and showed small horizontal ridges as though from the lateral pressure. Another example of buckling in the beds was observed on the walls of a gully five miles north of this place. This is probably in measures slightly higher in the series than this seam, and, if so, there is a chance that farther in on the measures workable parts may be found on this crushed seam.

The effect of this buckling on the coal above the plane of sliding will be to form waves as at the Canmore mine. Other sliding planes may, however, be encountered, but they are as apt to be in the shale beds as in the coal seams, and may not cause very much damage.

Bankhead Mine.

The development so far at Bankhead has disclosed in the lower part of the measures three very regular and little disturbed coal seams, a smashed portion of another, and in the cross-cut four very heavy seams above. The lower seams are nearly as hard as at Anthracite, but from the samples taken from the outcrops of the higher seams along the hillside softer coal will probably be found, and after the cross entries are finished the shipments may include anthracite and steam coal. The mining at Anthracite is all from a lower level than that at Bankhead, so that the difference in fixed carbon in the coal from the two localities may be due to this difference in level.

There seems good reason to suppose that part of this field was over-ridden by the limestone of Cascade mountain as well as a portion to the south which is now opposite the gap between Rundle and Cascade mountains probably to past Anthracite. One reference that points to this conclusion will be mentioned before giving details of the coal seams at Bankhead. A seam just under the foot of the mountain was prospected by a short slope which followed it down for one hundred feet. The seam started at the normal dip of 45 to 50 degrees, but was found broken in several places by faults running along in front of the mountain which carried the seam down so that from the bottom of the slope to the top the dip was nearly 80 degrees. This would tend to show that the part in the slope was just in front of the load, and the breaks the result of this immense weight. Beneath the load there would be less chance for folds, but on the sliding planes where these happen to be on coal seams the destruction would be carried far, though, in the unloaded portion this gradually becomes less, and the amount of displacement also decreases by reason of the folding giving relief.

A thickening of the measures in the unloaded part from the bending in the beds is also shewn in the change of dip at the foot of the mountain.

DETAILS OF THE SEAMS.

The manager, Mr. D. Stockett, very kindly furnished the details regarding the seams in the mine as shown by the cross-cut.

As work on this cross-cut tunnel is still in progress the details are complete only for the seams enumerated below. The beds are cut at an angle of about 45 degrees, so that the distances in the tunnel have to be reduced to show the horizontal distances between the seams, and then, from the dip of the beds, the thickness of strata can be ascertained.

From the highest seam then opened (No. 6), for which no details are given, the distance in this cross-cut tunnel to the next below, No. 5, is 173 feet, representing a horizontal distance of 122 feet at right angles to the strike. As the dip of the seam is here 30 degrees, this represents a thickness of 61 feet of strata between the seams.

Seam No. 5, dip 30 degrees:—

Coal	6′ 0″
Sandstone and slate	3′ 0″
Coal	0′ 8″
Slate	0′ 4″
Coal	0′ 7″
Slate	0′ 9″
Coal (dirty)	0′ 11″

Horizontal distance between No. 5 and No. 4 seams, 120 feet; thickness of beds, about 60 feet.

Seam No. 4, dip 20 degrees:—

Coal	6′ 0″
Mining	1′ 3″
Coal	3′ 0″
Sandy slate	2′ 6″
Coal	4′ 6″

Three hundred and sixty feet horizontally through sandstones to seam No. 3. The perpendicular distance between these seams is not as great as this distance would indicate, as there is some folding in the beds between.

Seam No. 3, dip 50 degrees:—

Roof, sandstone.	
Slate	1′ 0″
Coal	10′ 0″
Mining	0′ 6″
Coal	4′ 0″
Sandy slate	5′ 0″
Coal	5′ 0″
Sandy slate	2′ 0″
Slate	0′ 8″
Coal	0′ 4″
Slate	1′ 0″

One hundred and thirty-two feet horizontally through sandstones to seam No. 2. This represents about 92 feet of beds.

Seam No. 2, dip 50 degrees:—

Slate..	0′ 6″ to 1′ 6″
Coal..	1′ 0″ 1′ 3″
Mining..	0′ 4″ 0′ 6″
Coal..	8′ 0″
Sandy slate..	1′ 4″
Coal..	0′ 2″ to 0′ 4″
Sandstone..	2′ 0″
Coal..	0′ 3″ to 0′ 4″
Sandstone..	3′ 0″ 4′ 0″
Coal..	1′ 6″

Analysis of specimen from entry at B level.

Moisture..	0·43
Volatile combustible..	10·65
Fixed carbon..	85·02
Ash, white..	3·90
	100·00

Forty feet horizontally through sandstone to seam No. 1, about 30 feet of beds.

Seam No. 1, dip 50 degrees:—

Slate..	0′ 6″ to 0′ 10″
Coal..	4′ 0″
Mining..	1′ 0″
Coal..	1′ 6″
Sulphurus..	0′ 1″ to 0′ 3″
Coal..	1′ 0″
Slate..	0′ 4″ to 0′ 6″
Coal..	1′ 0″
Slate..	1′ 0″
Coal..	0′ 2″ to 0′ 3″
Slate..	1′ 0″
Coal..	0′ 3″ to 0′ 4″

Forty-four feet horizontally to seam No. 0.

Seam No. 0, dip 50 degrees:—

Sandy slate..	0′ 7″
Coal..	0′ 2″
Sandy slate..	1′ 2″
Coal..	0′ 4″
Slate..	0′ 6″
Bony coal..	0′ 6″
Coal..	2′ 6″

The measures in which these seams are found constitute a block dipping to the southwest toward the Cascade mountain. At the south end they seem to go under the limestones. At the north end the measures are bent up in an evident syncline, and the bottom of the measures are cut off at such an elevation that beyond where the valley is eroded nearer to the Cascade mountain the beds are entirely cut off.

A section measured near the mine at Bankhead gives a total of 2,800 feet as the thickness of possible coal-bearing rocks, with 550 feet of thin bedded brown sandstones and shales above them. The measures consist of sandstones and shales of a generally brown colour, and, in this vicinity, three strong sandstone ridges forming an upper and lower rib with one in the centre. These upper and lower ribs seem to define the limits of the coal formation. Below, a series of sandstones and shales very like those above the coal measures have a thickness of 1,100 feet. The passage to the Fernie

shales is conformable, and is marked by the absence of sandstone. The Fernie shale consists of 1,300 feet of dark grey to black shale overlying 240 feet of dark greyish thin sandstone, the whole of marine origin and assigned to the Jurassic period.

The sandstone rib below the coal measures is a fairly well marked feature of all the sections of the Cretaceous of the area, and is about the only means of tracing the measures up the valley of the Bow river. In the area between the Cascade and the Panther river these appear in the higher points toward the centre of the valley, showing the shallow nature of the coal areas there.

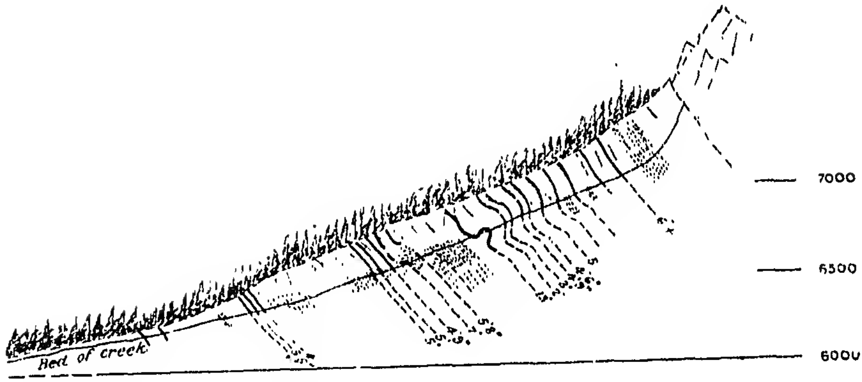
Sections in the gullies on the east face of Cascade mountain.—Natural exposures of the stronger measures are found in the gullies running from the face of the mountain, but to test the coal seams prospecting work was undertaken on nearly all these gullies. On a creek about three miles north of the present mine fourteen coal seams were uncovered in the upper 500 feet of the measures. This stream was called Coal creek, and the gullies north and south of this were given numbers. The prospecting was continued north to Creek No. 10 and south to Creek No. 6.

On Creek No. 5 south the temporary drifts or entries on the two lower seams at what is now B level were started. There were no exposures, but the seams were traced by Mr. Gwillim from exposures on Creek No. 4.

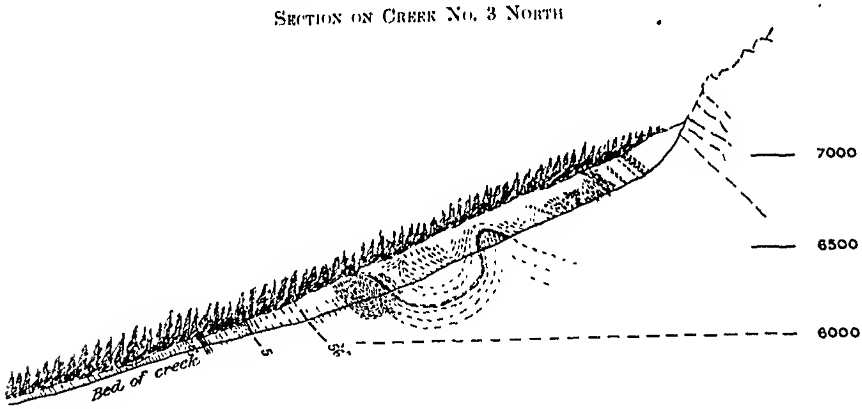
Section of Measures on Creek No. 3 North.

Measurements along creek bed:—

Upper sandstone rib.		
Thin bedded sandstone..		20 feet
Seam, dip 55°, shattered coal..	6′ 0″	
Sandstone and shale..		130 "
Seam G, tunnel caved in.		
Sandstone—at 100 feet, dip 35°..		178 "
Broken coal and grey slate.		
Unexposed..		114 "
Hole in bank with some coal dust and rock.		
Unexposed—at 50 feet grey sandstone vertical..		105 "
Small tunnel on vertical seam of coal..	5′ 0″	
Unexposed..		42 "
Seam of dirty coal..	2′ 0″	
Unexposed..		40 "
Vertical seam of coal..	4′ 6″	
Unexposed..		50 "
Coal seam nearly vertical..	4′ 9″	
Unexposed..		66 "
Open cut showing broken coal, about..	3′ 0″	
Unexposed..		44 "
Open cut showing broken coal..	2′ 0″	
Covered..		100 feet
Coal seam..	13′ 0″	
Same seam is repeated farther down the creek by an anticline in the beds and an abrupt upturn. At the distance stated above there is a tunnel on the broken coal and a cross-cut in coal for forty feet along the bottom of the upturn.		
Unexposed..		342 "



SECTION ON CREEK NO. 3 NORTH



SECTION ON CREEK NO. 6 NORTH.

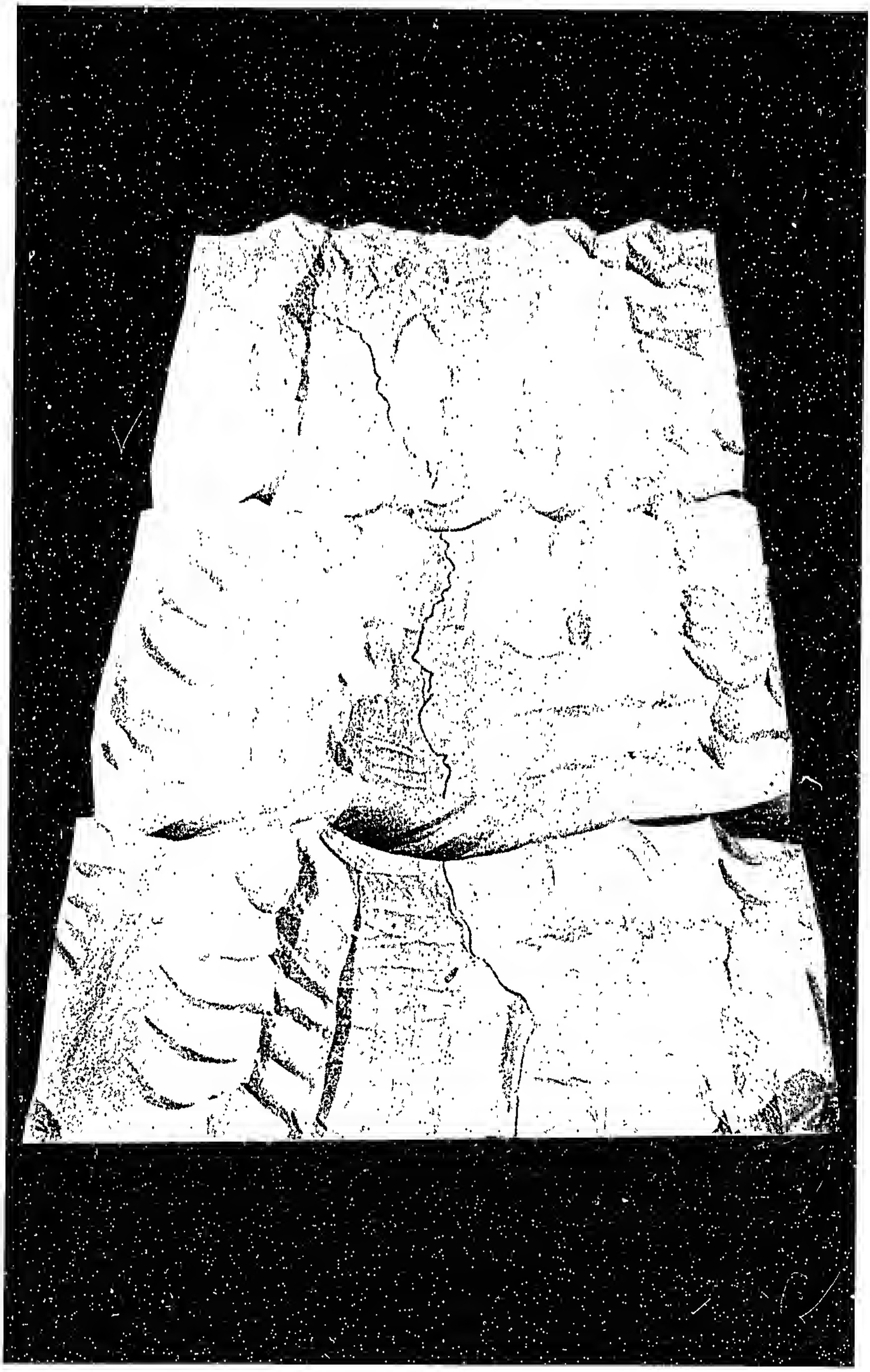
Coal seam—Dip, 36° S.W.—

Coal		1′ 0″	
Slate		0′ 6″	
Coal		4′ 8½″	
Total coal		5′ 8½″	
Covered			78 feet.
Coal	7′ 0″	dip 54°	
Covered			107 "
Coal	4′ 9″	dip 46°	
Covered			77 "
Coal	5′ 0″	dip 45°	
Sandstones and shale			47 "

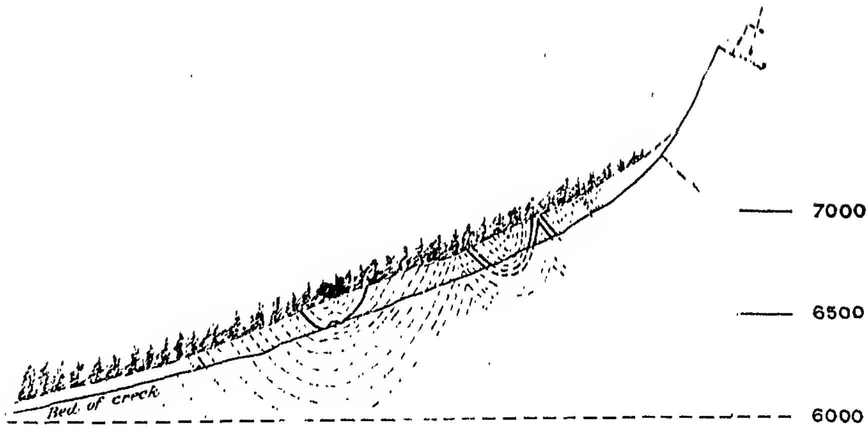
Seam roof dark slate; dip, 50° S.W.

Coal	1′ 6″	
Slate	0′ 4″	
Coal	5′ 0″	
Shales and sandstones		702 "

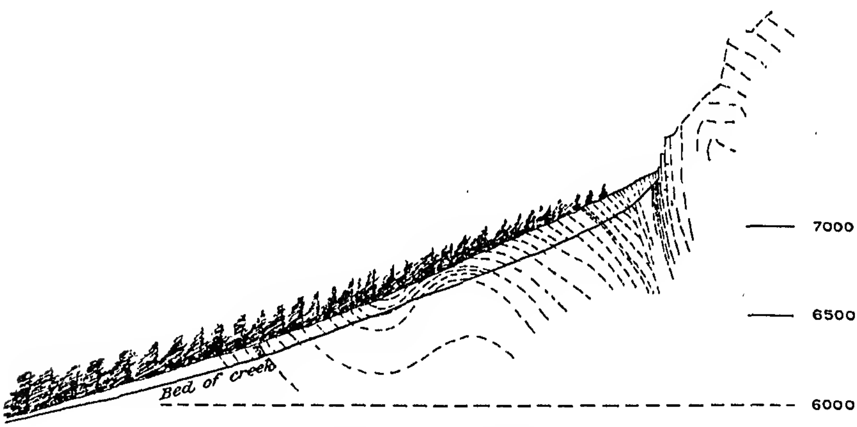
Three small seams, dip 46°.
Roof, clayey sandstone.



26b.—p.32. MODEL OF CASCADE VALLEY.



SECTION ON CREEK No. 7 NORTH.



SECTION ON CREEK No. 10 NORTH.

Coal..	1′ 0″	
Slate..	0′ 6″	
Coal..	0′ 6″	
Slate..	0′ 5″	
Coal..	3′ 0″	
Covered..		51 feet.
Coal seam 5′ 5″, with yellow sandstone nodules in centre.		
Covered..		31 "
Tunnel on coal seam..	6′ 0″	

This has been run in about 50 feet, and shows about 6 feet of coal, to a sandstone rib, a distance of 144 feet. There are two coal seams below this at about 400 feet, near which point is, possibly, the lower sandstone rib.

Creeks Nos. 4 and 5 north have few exposures, but several of the seams noted on No. 3 have been found. As the great mass of loose material that the stream has brought down has filled its bed, good sections are not seen. This is unfortunate, for,

between No. 3 and No. 6 there is evidence that there is a change from the comparatively undisturbed beds on No. 3 to a compound fold with local irregular bends on No. 6. The illustrated sections for these creeks show the change to a deep synclinal trough on No. 10. The upper measures also seem to have been cut off by the fault, and the lower measures are the only ones that reach as far as Creek No. 10.

PANTHER RIVER COAL AREAS.

Three distinct coal areas are crossed by this stream before it issues from the mountains. That which is in almost direct line and connected with the one through which the Bow river passes is here extremely shallow, and very little of the coal-bearing rocks are found. The area to the east of this is not of great extent, but may prove to have some workable coal seams, while the third area, just within the mountains, is larger, and is described in the summary report of this department for 1904. The report is accompanied by a map of the portion which is most accessible, namely, that near the Panther river. The structure of the three basins and their relation to each is illustrated in a section on the margin of the Costigan map (No. 892).

PALLISER AREA.

The central area which is mapped on the Panther sheet of the Cascade basin is there referred to as the Palliser basin. This name is used because the area is within the mountains forming the Palliser range, as distinct from the basin to the west through which the Cascade river cuts. This coal area, as will be seen from the map, is not of large extent south of the Panther river, and although the depression is wide the coal rocks are found only on the higher hills. Along the fault line east of the Bare mountains to the north of this stream the limestones are brought against the pushed up and crushed edges of the coal rocks which dip generally toward the fault, and in the narrow strip just to the east of this line through these foothills there is probably sufficient coal to pay for working. This is easily accessible from the valley of the stream. On the higher points of several hills in the valley the lower parts of folds in the coal measure remain, and coal seams are in evidence, but they are very much crushed, and turn up at each side of the hill, so that there is little coal in the exposure. Other seams, the continuation of these fragments, were, however, found in the high ground nearer the fault line. On the south side of the river the most prominent ridge rising from the east slope of the mountain ridge showed very good sections in a deep ravine, and here two coal seams dip downward toward the west after passing through a deep fold at the eastern edge of the escarpment. The lowest seam is of bright, hard coal, two feet in thickness, and gives the following analysis, according to Dr. Hoffman:—

Moisture	1·13
Volatile combustible matter	11·59
Fixed carbon	84·94
Ash	2·34
	100·00

This coal does not make a coherent coke, so that it is as hard or harder than that at Canmore, but is very clean and free from ash.

Above this another seam was uncovered, but was of much duller lustre and appeared more crushed. The thickness here is five feet, with soft shale and sandstone

roof, and, like the first, does not coke. The analysis supplied by Dr. Hoffmann gives:—

Moisture	0·03
Volatile combustible matter	10·58
Fixed carbon	83·55
Ash	4·04
	100·00

On the north side of the stream these seams were not discovered, but there is a probability that they continue across, and as there is a larger area which is occupied by these rocks there should be more seams than those already found.

CASCADE TROUGH.

Although a wide belt of Cretaceous rocks occupies the basin, the greater part is taken up by the lower members of the series, and the larger part of the area shown on the Panther River sheet is in the form of a trough, the lower Cretaceous beds continuing across and forming a belt along the western margin. In this part the higher beds containing the coal appear only in the hills between the limestone mountain ridges, and show that there were very strong folds in the upper beds, as all the exposed coal-bearing rocks are very much bent in folds which apparently follow the general direction of the valley. As coal areas, those south of the Panther river are not of any great moment on account of their size and position, and the character of the seams, which are very much crushed and bent.

North of the river this broad shallow basin, which is terminated on each edge by an upturn of the lower beds, is gradually narrowed, and as the highland between the Panther and Red Deer river is approached the form is changed to that of a monocline or a block in which the beds dip in one general direction, in this case toward the upheaved rocks that form the Vermilion range. The coal-bearing rocks, which in the shallow basin appear only on the summits of the hills, here again form a narrow strip along the west side in very much the same manner as along the face of the Cascade mountains.

The division between the two types of structure is marked by a heavy fold running from the fault line, at the height-of-land mentioned above, southeastward to the centre of the valley as far as the high land of these Cretaceous hills extends. Northward, the beds dip toward the fault line with less disturbance, and a few seams were noted that might repay exploiting. The lower seams observed near the Panther river in the Palliser basin just to the east are found again here in the hills at the height-of-land in a hill to the south of a small lake which drains to the Red Deer. The coal here seems to be soft and very much crushed. The expectation that this would prove as hard as in the Palliser basin was not realized, and the coal of the five-foot seams is reported by Dr. Hoffmann as making a firm compact coherent coke. The analysis of this sample gave:—

Moisture	0·72
Volatile combustible matter	21·28
Volatile combustible matter	75·80
Ash	2·20
	100·00

Coke per cent, 78·00.

Another seam in the ridge to the north of this lake, much higher in the series, is reported by my assistant, Mr. G. E. Malloch. This is of the same general character as the five-foot seam just noted, but there is a much greater thickness,—over seven feet. That the coal in this vicinity is generally of a softer character is also shown by an analysis given by Dr. Dawson for a seam observed on the Red Deer river a few miles north of this map. Prow mountain is the northern end of the Vermilion range

as it reaches the valley of the Red Deer. The following quotation contains the information we have at present for the seams there exposed. 'In the northern face of Prow mountain—a bare, bold, limestone peak—the overturned character of the western edge of the Cretaceous trough is clearly seen. On the Red Deer, at its base, and quite close to the overlapping edge of the limestones, is an exposure showing a coal seam several feet in thickness, but so much crumpled and broken that the precise width could not be ascertained. Coal was also observed in the bed of a stream joining the river from the north. A specimen from the bed on the river was found to yield a firm coke, and to be, so far as composition goes, an excellent fuel, giving 2·0 per cent of hygroscopic water, 62·95 per cent of fixed carbon and only 4·80 per cent of ash. (See p. 7 M., Vol. 1.)'*

FERNIE SHALE.

The dark shales that underlie the sandy measures constituting the Kootanie series of Dawson are well represented in many exposures in the area covered by the accompanying maps. The principal exposures are to be seen on the following streams: (1) Stream flowing along the west slope of Pigeon mountain; (2) Cascade river; (3) Panther river; (4) Snow creek.

Of these the chief are those of the Cascade, and give the best section of its thickness. The stream, from where it crosses the Cascade mountain ridge through a gap caused by a cross fault, flows generally on the dark shales. About five miles above the mouth of Devil creek it turns to the east and then southward to follow approximately a line of fault in the limestone range. Below this it again crosses the limestone ridge through a narrow gorge, and before it joins the Bow river has crossed the dark shales and nearly the whole section of the Cretaceous. On this part it cuts the measures at nearly right angles, the thickness of the formation, as here obtained, measuring 1,600 feet.

In the lower part the rocks are of a lighter colour, and consist of dark grey sandstones and shales, but these grade upward into very dark shales. The whole formation seems to be of marine origin, as the only fossils collected in this special district consist of a few Belemnites, but larger collections have been obtained in small exposures to the east. In 1887 Mr. McConnell collected from a small outlier of these shales near the east end of Lake Minnewanka (Devil lake) a series of ten marine species,* eight of which are found in the lower part of the Queen Charlotte Islands coal-bearing rocks. These latter have since been determined as Jurassic. The typical locality near Fernie has supplied but few fossils, but one of these *Cardioceras canadense*, is undoubtedly Jurassic.

The exposures in the Cascade valley indicate some disturbance during the mountain building operations to the lower members of this series. On the pack trail across the loop made by the river into the limestone ridge to the east it is found that a depression, which may at one time have been followed by the creek, runs along the line of contact between the dark shales and the underlying dolomite limestones which form the top of the Upper Banff shales. Into this old valley, which now is about seventy-five feet above the Cascade at its northern end, creeks No. 1 south, Coal creek and No. 1 north flow, to turn northward to the Cascade. At the small gorges made by each on entering the valley the grey sandstone and shales of the lower part of the Cretaceous are seen, but they are bent in a reversed curve showing a slight yielding to the lateral pressure from the overthrust at the west. Near the mouth of Creek No. 3, on the Cascade, the same sandstone and shales outcrop, but they are not bent as sharply.

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* Annual Report, Geol. Surv., Can., Vol. I. (N.S.), p. 146 B.

* Vol. I., part III., Contributions to Canadian Palaeontology.

Very few exposures that can be considered as near the base of the formation are seen in the banks of Cascade river until the east branch is reached, where again the contact is seen, but there seems less disturbance on the lower measures. The basin here is much shallower, and the overthrust of the west side seems changed to a reversed fold, so that there is more chance that the members of the series which occupy the concave side are slidden against one another than in the thick monoclinal block at the south end of Cascade mountain. The folds at the mouth of Creek No. 3 and at the bend north on Coal creek must indicate a slight slip along the bedding planes which dies out to the south. Another point of possible disturbance in these lower shales is along the continuation of the fault line in the limestone range to the east, at the cañon on the Cascade. The throw of this fault becomes less toward the south and runs out toward the main valley above Canmore. Exposures of the lower shales occur on the creek joining the Bow from behind Pigeon mountain. Most of the exposures on it are of the red shales of the Upper Banff, probably Carboniferous, but a portion of the black shales of the Lower Cretaceous section also appears. In this a few Belemnites were found.

APPENDIX I.

REPORTS REFERRING TO GEOLOGY AND STRUCTURE OF THIS AREA.

(1) Preliminary Report on the Physical and Geological features of the Rocky Mountains. By George M. Dawson. Part B., Annual Report, Vol. 1. (1885).

(2) Report on the Geological Structure of a portion of the Rocky Mountains. R. G. McConnell. Part D., Annual Report, Vol II. (1886).

(3) Summary Report of the Geological Survey Department, 1903, p. 88. D. B. Dowling.

(4) Summary Report of the Geological Survey Department, 1904, p. 107. D. B. Dowling.

(5) The Stratigraphy of the Cascade Coal Basin. By D. B. Dowling. Journal of Canadian Mining Institute, Vol. VIII.

SELECTED LIST OF REPORTS

(SINCE 1885)

OF SPECIAL ECONOMIC INTEREST

PUBLISHED BY

THE GEOLOGICAL SURVEY OF CANADA

MINERAL RESOURCES BULLETINS

818. Platinum.
851. Coal.
854. Asbestus.
857. Infusorial Earth.
858. Manganese.
859. Salt.
860. Zinc.
869. Mica.
872. Molybdenum and Tungsten.
877. Graphite.
880. Peat.
881. Phosphates.
882. Copper.
913. Mineral Pigments.

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745. Altitudes of Canada, by J. White. 1899. (40c.)

BRITISH COLUMBIA.

212. The Rocky Mountains (between latitudes 49° and 51° 30′), by G. M. Dawson. 1885. (25c.).
235. Vancouver Island, by G. M. Dawson. 1886. (25c.).
236. The Rocky Mountains, Geological Structure, by R. G. McConnell. 1886. (20c.).
263. Cariboo mining district, by A. Bowman. 1887. (25c.).
272. Mineral Wealth, by G. M. Dawson.
291. West Kootenay district, by G. M. Dawson. 1888–89. (35c.).
573. Kamloops district, by G. M. Dawson. 1894. (35c.)
574. Finlay and Omenica Rivers, by R. G. McConnell. 1894. (15c.)
743. Atlin mining district, by J. C. Gwillim. 1899. (10c.)
939. Rossland district, B.C., by R. W. Brock.
940. Graham Island, B.C., by R. W. Ells, 1905. (10c.)

YUKON AND MACKENZIE.

260. Yukon district, by G. M. Dawson. 1887. (30c.)
295. Yukon and Mackenzie Basins, by R. G. McConnell. 1889. (25c.)
687. Klondike gold fields (preliminary), by R. G. McConnell. 1900. (10c.)
884. Klondike gold fields, by R. G. McConnell. 1901. (25c.)
725. Great Bear Lake and region, by J. M. Bell. 1900. (10c.)
908. Windy Arm, Tagish Lake, by R. G. McConnell. 1906. (10c.)

ALBERTA.

237. Central portion, by J. B. Tyrrell. 1886. (25c.)
324. Peace and Athabaska Rivers district, by R. G. McConnell. 1890-91. (25c.)
703. Yellow Head Pass route, by J. McEvoy. 1898. (15c.)

SASKATCHEWAN.

213. Cypress Hills and Wood Mountain, by R. G. McConnell. 1885. (25c.)
601. Country between Athabaska Lake and Churchill River, by J. B. Tyrrell and D. B. Dowling. 1895. (15c.)
868. Souris River coal fields, by D. B. Dowling. 1902. (10c.)

MANITOBA.

204. Duck and Riding Mountains, by J. B. Tyrrell. 1887-8. (10c.)
206. Glacial Lake Agassiz, by W. Upham. 1889. (25c.)
325. Northwestern portion, by J. B. Tyrrell, 1890-91. (25c.)
704. Lake Winnipeg (west shore), by D. B. Dowling. 1898. } Bound together.
705. " (east shore), by J. B. Tyrrell. 1898. (25c.) }

KEEWATIN AND FRANKLIN.

217. Hudson Bay and strait, by R. Bell. 1885. (15c.)
238. Hudson Bay, south of, by A. P. Low. 1886. (10c.)
239. Attawapiskat and Albany Rivers, by R. Bell. 1886. (15c.)
244. Northern portion of the Dominion, by G. M. Dawson. 1886. (20c.)
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618. Northern Keewatin, by J. B. Tyrrell. 1896. (30c.).
787. Grass River region, by J. B. Tyrrell and D. B. Dowling. 1900. (25c.)
815. Ekwan River and Sutton Lakes, by D. B. Dowling. 1901. (15c.)
905. The Cruise of the *Neptune*, by A. P. Low. 1905. ($2.00).

ONTARIO.

215. Lake of the Woods region, by A. C. Lawson. 1885. (25c.)
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266. Lake Superior, mines and mining, by E. D. Ingall. 1888. (25c.)
326. Sudbury mining district, by R. Bell. 1890-91. (20c.)
327. Hunters island, by W. H. Smith. 1890-90. (20c.)
332. Natural Gas and Petroleum, by H. P. H. Brumell. 1890-91. (25c.)
357. Victoria, Peterborough and Hastings counties, by F. D. Adams. 1892-93. (10c.)
627. On the French River sheet, by R. Bell. 1896. (10c.)
678. Seine River and Lake Shebandowan map-sheets, by W. McInnes. 1897. (20c.)
672. Nipissing and Timiskaming map-sheets, by A. E. Barlow. 1896. (In Vol. X. 80c.)
723. Iron deposits along Kingston and Pembroke Ry., by E. D. Ingall. 1900. (25c.)
730. Carleton, Russell and Prescott counties, by R. W. Ells. 1899 (25c.)(See No. 739 Quebec).
741. Ottawa and vicinity, by R. W. Ells. 1900. (15c.)
790. Perth sheet, by R. W. Ells. 1900. (10c.)
873. Sudbury Nickel and Copper deposits, by A. E. Barlow. (In Vol. XIV. 80c.)

QUEBEC.

216. Mistassini expedition, by A. P. Low. 1884-5. (10c.)
240. Compton, Stanstead, Beauce, Richmond and Wolfe counties, by R. W. Ells. 1886. (25c.)
268. Mégantic, Beauce, Dorchester, Lévis, Bellechasse and Montmagny counties, by R. W. Ells. 1887-8. (25c.)
297. Mineral resources, by R. W. Ells. 1889. (25c.)
328. Portneuf, Quebec and Montmagny counties, by A. P. Low. 1890-91. (15c.)
579. Eastern townships, Montreal sheet, by R. W. Ells and F. D. Adams. 1894. (15c).
670. Auriferous deposits, Southeastern portion, by R. Chalmers. 1895. (20c.)
591. Laurentian area north of the Island of Montreal, by F. D. Adams. 1895. (15c.)
672. Timiskaming map-sheet, by A. E. Barlow. 1896. (30c.) (In Vol. 10. 80c.)
707. Eastern townships, Three Rivers sheet, by R. W. Ells. 1898. (20c.)
739. Argenteuil, Wright, Labelle and Pontiac counties, by R. W. Ells. 1899. (25c.) (See No. 739, Ontario).
788. Nottaway basin, by R. Bell. 1900. (15c.)
863. Wells on Island of Montreal, by F. D. Adams. 1901. (30c.)
923. Chibougamou region, by A. P. Low. 1905. (10c.)

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217. Hudson Strait and Bay, by R. Bell. 1885. (15c.)
267. James Bay and east of Hudson Bay, by A. P. Low. 1887-88. (25c.)
584. Labrador Peninsula, by A. P. Low. 1895. (30c.)
657. Richmond Gulf to Ungava Bay, by A. P. Low. 1896. (10c.)
680. Hudson Strait (south shore) and Ungava Bay, by A. P. Low. 1898. (15c.) } Bound together.
713. Hudson Strait (north shore), by R. Bell. 1898. (20c.) }
778. Hudson Bay, east coast, by A. P. Low. 1901. (25c.)
819. Nastapoka Islands, Hudson Bay, by A. P. Low. 1901. (10c.)

NEW BRUNSWICK AND NOVA SCOTIA.

218. Western New Brunswick and Eastern Nova Scotia, by R. W. Ells. 1885. (20c.)
219. Carleton and Victoria cos., by L. W. Bailey. 1885. (20c.)
242. Victoria, Restigouche and Northumberland counties, N.B., by L. W. Bailey and W. McInnes. 1886. (10c.)
243. Guysborough, Antigonish, Pictou, Colchester and Halifax counties, N.S., by Hugh Fletcher and E. R. Faribault. 1886. (25c.)
269. Northern portion and adjacent areas, by L. W. Bailey and W. McInnes. 1887-88. (25c.)
330. Temiscouata and Rimouski counties, by L. W. Bailey and W. McInnes. 1890-91. (10c.)
331. Pictou and Colchester counties, N.S., by H. Fletcher. 1890-91. (20c.)
358. Southwestern Nova Scotia (Preliminary), by L. W. Bailey. 1892-93. (10c.)
628. Southwestern Nova Scotia, by L. W. Bailey. 1896. (20c.)
661. Mineral resources, N.B., by L. W. Bailey. 1897. (10c.)
New Brunswick geology, by R. W. Ells. 1887. (10c.)
797. Cambrian rocks of Cape Breton, by G. F. Matthew. 1900. (50c.)
799. Carboniferous system in N.B., by L. W. Bailey. 1900. (10c.) } Bound together.
803. Coal prospects in N.B., by H. S. Poole. 1900. (10c.) }
871. Pictou coal field, by H. S. Poole. 1902. (10c.)

IN PRESS.

977. Report on Pembroke sheet, Ont. and Que., by R. W. Ells.
949. Report on Cascade Coal Basin, by D. B. Dowling.
953. Mineral Resources Bulletin, Barytes, by H. S. Poole.
970. Report on Niagara Falls, by Dr. J. W. Spencer.
968. Report to accompany map of the Moose Mountain area, Altn., by D. D. Cairnes.
961. Reprint of No. 873.
962. " No. 672.

IN PREPARATION.

Rossland district, B.C. (full report), by R. W. Brock.
Report on Prince Edward county, Brockville and Kingston map sheet, by R. W. Ells.
Report on Cornwall sheet, by R. W. Ells.
Reports on Country between Lake Superior and Albany river, by W. J. Wilson and W. H. Collins.